



# New Organizational Forms, Learning and Incentive-Based Inequality

Patricia Crifo, Marie Claire Villeval

## ► To cite this version:

Patricia Crifo, Marie Claire Villeval. New Organizational Forms, Learning and Incentive-Based Inequality. 2001. halshs-00179984

**HAL Id: halshs-00179984**

**<https://shs.hal.science/halshs-00179984>**

Submitted on 17 Oct 2007

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

**DOCUMENTS DE TRAVAIL - WORKING PAPERS**

**W.P. 01-10**

**New Organisational Forms, Learning and Incentives-based  
Inequality**

Patricia Crifo-Tillet, Marie-Claire Villeval

2001

GATE Groupe d'Analyse et de Théorie Économique  
UMR 5824 du CNRS  
93 chemin des Mouilles – 69130 Écully – France  
B.P. 167 – 69131 Écully Cedex  
Tél. +33 (0)4 72 86 60 60 – Fax +33 (0)4 72 86 60 90  
Messagerie électronique [gate@gate.cnrs.fr](mailto:gate@gate.cnrs.fr)  
Serveur Web : [www.gate.cnrs.fr](http://www.gate.cnrs.fr)

# New Organisational Forms, Learning and Incentive-based Inequality

## Nouvelles formes d'organisation, apprentissage et inégalités fondées sur les incitations

Patricia Crifo-Tillet<sup>1</sup>

Marie-Claire Villeval<sup>2</sup>

GATE<sup>3</sup>

GATE<sup>4</sup>

Université Lumière Lyon 2

WP 01-10

### Abstract

This paper analyses the influence of organisational change on the widening of earnings inequality, depending on the nature of employers' policy with respect to both how to deal with moral hazard problems and how to manage the access to skills. In a linear agency model which explains organisational change from an incentive perspective, we show that new job design is inequality increasing. However, the extent of inequality depends on the principal's strategy for managing the access to the higher skills required by organisational change: selective hiring vs. in-house training. Training reveals to be another incentive device added to monetary schemes or delegation. By comparison with the selective hiring strategy, training entails a lower average wage and a lower expected wage gap between- and within-skill groups.

**Keywords:** Incentives, Job design, Learning, Organisational innovation, Principal-Agent Relationship.

### Résumé

En lien avec l'analyse des inégalités et du biais de qualification imputable aux innovations, cet article développe un modèle théorique destiné à rendre compte de l'influence de l'organisation du travail sur les incitations et les revenus. A l'aide d'un modèle d'agence linéaire, qui explique les innovations organisationnelles sous l'angle des incitations, nous montrons, dans une perspective statique, que l'impact des formes d'organisation sur les revenus espérés peut être décomposé en deux effets (un effet de prime de risque et un effet de complémentarité des tâches dont l'origine se trouve dans l'apprentissage et la diffusion de l'information). Ces effets orientent la productivité et les paiements espérés à la hausse, ce qui correspond aux faits observés dans de nombreuses études empiriques. Ainsi, le développement de nouvelles pratiques organisationnelles fondées sur un degré plus important de délégation contribue à l'accroissement des inégalités. Dans une perspective dynamique, le modèle montre que la diffusion du savoir soutient en général la même tendance. Cependant, lorsque les efforts initiaux et la productivité sont importants, le produit et les revenus diminuent lors de la phase de transition vers l'état stationnaire. L'impact global du changement organisationnel sur les revenus et les inégalités est ambigu, dépendant finalement de l'importance du phénomène d'apprentissage.

**Mots-cles:** incitations, job design, apprentissage, innovation organisationnelle, relations principal-agent.

**JEL classification:** F23; L10

---

<sup>1</sup> crifo-tillet@gate.cnrs.fr

<sup>2</sup> villeval@agte.cnrs.fr

<sup>3</sup> Groupe d'Analyse et de Théorie Economique, UMR 5824 du CNRS - 93, chemin des mouilles, 69130 Ecully - France. Tel: +33 472 86 60 60 Fax: +33 472 86 60 90

<sup>4</sup> We would like to thank P. Askenazy, E. Caroli, E. Lehmann, and participants at the 1999 EALE conference, along with two anonymous referees for helpful suggestions on an earlier version of this paper. The usual disclaimer applies

# 1 Introduction

Over the past ten years, many firms have experienced the introduction of new organisational modes in order to improve the quality and variety of products, reduce the time to market, and implement lean production schedules. Organisational innovation requires, to some extent, overcoming certain occupational barriers, along with developing multi-skilling as opposed to specialisation. In order to cope with greater task diversification, new work practices have been emerging, thereby inducing the development of more horizontal communication channels, a reduction of supervisory layers in favour of flatter organisations, increased employee autonomy and a broader span of control at the remaining levels (Appelbaum and Batt, 1994; Bresnahan, Brynjolfsson and Hitt, 1998; Caroli and Van Reenen, 1999; Snower, 1999). Innovative work practices are naturally designed to improve firms' performance; recent growth in productivity in many OECD countries appears to be linked to the emergence of a "New Economy", driven by innovation in technology and work organisation (Black and Lynch, 2000).

In the meantime, wage inequality has been rising both between and within educational groups (Juhn et al., 1993). A popular explanation for this phenomenon is to attribute the widening earnings gap to a greater pace of skill-biased technical change (see, among others, Bound and Johnson, 1992; Doms, Dunne and Troske, 1997). However, if one acknowledges, as have Helpman and Trajtenberg (1994), that in order to benefit from computerisation, firms have to redesign their work organization (e.g. through emphasising teamwork over hierarchical links), changes in technology and changes in organisation should thus be intimately related. Yet, the link between organisational change and increasing earnings inequality is by far less well-documented than the technological bias hypothesis. Many articles have stressed the impact of the dissemination of new information and communication technologies on the declining demand for less-educated workers (Berman, Bound and Griliches, 1994; Betts, 1997; Chennels and Van Reenen, 1998). However, through both new skill requirements and new forms of flexibility, organisational innovation may also exert an influence on the generation of inequality. For instance, since innovative firms rely more heavily upon multi-skilled agents, these firms may increase the skill premium in order to compete in non-competitive labour markets to attract highly-educated workers. In addition, under certain conditions, organisational innovation can increase segregation in the labour

market by relegating low-skilled workers to the secondary labour market (Kremer and Maskin, 1996). At the aggregate level in the U.S., the wage levels in reorganised sectors increased between 1983 and 1994, and the rising productivity gap between reorganised and non-reorganised sectors explains in part the growth of within-group inequality. Moreover, in the U.S., between-group inequality has been increasing more in reorganised sectors (Askenazy, 1998). Thus, one has to identify how far innovative work practices have played a part in skill-biased innovation through contributing to the dramatic increase in earnings inequality, to the benefit of high-skilled labour in most developed countries during the 1980's. However, it should also be noted that the relationship between education and organization is open to debate. Individuals' educational choices may stimulate the implementation of organisational innovation, which in turn requires more highly-educated workers. In other words, organisational change may be biased not by nature but "by design" (as demonstrated about new technologies by Acemoglu, 1998), thus extending wage inequalities (Crifo-Tillet and Villeval, 1999). Thus, it is important to analyze the complex relationships between education, organisational forms and earnings inequality.

Even in recognising that knowledge-based economies tend to increase wage inequality through changes in work organisation, this relationship is still highly ambiguous. On the one hand, the requirement of higher educational achievements for coping with organisational change can be inequality-enhancing: if new organisations require multi-skilled agents and if highly-educated workers are needed to perform multi-skilled tasks, inequality then increases through the rise of the education premium. On the other hand, both the degree of task delegation and the firm's strategy for managing the access to skills can counteract the influence of rising educational requirements on widening inequality. As forwarded by Aghion, Caroli and García-Peñalosa (1999), the influence of organisational innovation largely depends on firms' policy with respect to human resources management. For example, the reduction in the number of hierarchical layers increases the problem of moral hazard within teams. If the employer delegates authority to a small number of employees within a team composed of homogeneous, highly-skilled workers, it will foster within-group wage inequality, even inside the firm. In contrast, if delegation is exercised to a large number of team members, the extent of within-group inequality inside the firm is restrained.

The present article, which focuses on this ambiguous relationship, aimed at analysing the influence of organisational forms on expected payoffs, depending on the nature

of employers' policy with respect to incentives and learning in order to handle moral hazard problems. We develop herein a linear agency model in which organisational design is analysed from an incentive perspective, whereas most analyses of the skill bias focus on labour demand shifts. In other words, we abstract from employment considerations in order to focus on job design. Although we recognize the importance of this issue, it remains outside the scope of this article, which highlights the impact of organisational forms on earnings in the absence of demand-side effects. This perspective finds support from the French manufacturing sector where, according to Greenan (1996), the employment behaviour of firms is affected more by changes in technology than by changes in work organisation.

The theoretical model developed in this article analyses organisational forms by taking into account job design and delegation within firms. In a principal-multi-agent relationship, the top manager (the principal) must determine how to allocate tasks among her subordinates. Two opposite cases are considered: in the specialised organisation, each agent is allocated one specific task; and in the multi-task organisation, each agent is delegated all tasks. This framework relies on the model developed by Holmström and Milgrom (1987) in its simplest form, as given in Itoh (1994). In this way, we are able to keep the basic assumptions as close as possible to those of the basic model. Yet, we extend Itoh's static analysis by introducing dynamic concerns of learning-by-doing that play an important role in organisational change. If the motivation underlying organisational change is far beyond the scope of this article, our aim herein is to provide theoretical grounds to recent empirical observations in innovative human resources management.

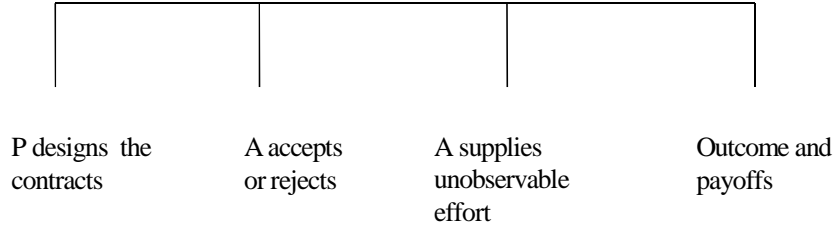
We have derived two key sets of results from this theoretical model. First, from a comparative statics analysis, multi-tasking generates not only higher effort but also higher within-group inequality as compared to the benchmark situation of specialisation. Second, from a dynamic perspective, a positive externality of learning-by-doing generates an upward effort and payoffs curve. During their transition to steady-state, efforts and payoffs will in general increase monotonically. However, new work practices featuring both incentive compensations and learning-driven complementarity between tasks do not *per se* and ineluctably foster wage inequality. As a matter of fact, if the initial effort level in the economy is relatively high (i.e. above its steady-state value), efforts and payoffs will then decrease to their respective steady-state values.

The remainder of the article is organised as follows. In Section 2, the role of

incentives in various organisational modes is considered. The model establishes the extent of incentives and performance associated with organisational features. In Section 3, the influence of human resources policy on payoffs is analysed through the role of learning, firstly in a static perspective, then in a dynamic perspective. Section 4 provides a conclusion.

## 2 Does multi-tasking increase incentives?

This section analyses the organisational structure at the level of the production unit. The nature of tasks to be delegated to workers is considered in a simple principal-agent model with moral hazard, in accordance with Holmström and Milgrom (1987) and Itoh (1994). The sequencing of the game is given as follows:



*Figure 1: Baseline structure of the agency relationship*

The outcome of the relationship between principal and agent is a homogeneous good that requires two different activities (or tasks) to be performed,  $i = 1, 2$ . The organisational features of the unit are embedded into its decision-making process. It is being assumed that the unit belongs to a principal who cannot perform the tasks herself due to time limitations. Thus, she must hire agents to whom these tasks can be delegated. Production is subject to moral hazard since workers' efforts are imperfectly observable by the principal. A contract between the principal and the agents consists of both a task allocation mode and payment schemes to agents. Moreover, following Holmström and Milgrom (1987), it is assumed that the principal is risk neutral whereas agents are risk averse, with a coefficient of absolute risk aversion identical for all agents and set equal to  $r$ .

Two different types of task delegation are analysed. First is a specialised delegation, in which two agents are hired with each assigned to perform a specific task. This delegation mode will be referred to as "specialised organisation": the principal decides

who is to perform which task. The second delegation mode is denoted the “multi-task organisation”: one agent is assigned to perform both tasks. By considering delegation in these terms, work organisation is considered explicitly as a strategic variable being determined endogenously by firms. Specialisation is a traditional work organisation, whereas multi-tasking represents an innovative practice, subject to productivity gains, as seen below. The debate over whether new human resources management leads to significant productivity gains has not yet reached a consensus. However, our assumption that multi-tasking exerts a positive impact on performance is consistent with several recent empirical studies (see Cappelli and Neumark, 1999; Ichniowsky, Shaw and Prennushi, 1997; Black and Lynch, 2000; Greenan, 1996).

## 2.1 The specialised organisation

In the specialised unit, the principal delegates both tasks, assigning one to each worker. Agents are identical and get assigned to a task arbitrarily. Assuming that tasks differ from one to the other by the nature of the skills required does not change the qualitative results of the model, but simply complicates the notations. This specialisation in tasks is consistent with a “tayloristic” organisation of work based on a strict division of tasks.

The observable output is of the specific form:

$$y^s = e_1^s + e_2^s + \varepsilon$$

where  $e_i^s$  is the unobservable effort at task  $i$  and  $\varepsilon$  is an error term, normally distributed with a mean of zero and variance  $\varphi^2$ . This equation suggests that single-period profits have mean  $e_1^s + e_2^s$  and variance  $\varphi^2$ . The index  $i$  denotes both the task and the agent performing this task.

The agent, when performing his assigned task, incurs a private cost. Following Itoh (1994), the cost function is quadratic with respect to the agent’s level of effort:

$$C(e_i^s) = \frac{1}{2}c(e_i^s)^2 \tag{1}$$

where  $0 < c < 1$  represents the slope of the marginal effort cost of the worker at his task, and  $e_i^s$  is the amount of effort worker  $i$  devotes to task  $i$ .

We have made use of Homlström and Milgrom’s result, which states that in such a linear agency model, simple linear contracts are more robust and even optimal (see



Holmström and Milgrom, 1987; Salanié, 1997). The payment scheme is therefore linear and given by:

$$w_i^s(y^s) = \alpha_i^s y^s + \beta_i^s$$

where  $\alpha$  is a share parameter, and  $\beta$  a lump sum allowing transfers between the principal and the agents.

Let's consider a linear compensation scheme corresponding to situations in which employees are compensated in the form of piece rates or commissions to sales agents. This compensation strategy implemented by the principal is empirically supported by the data to a substantial extent, although a much greater diversity in remuneration practices actually exists. This practice offers the feature of precisely reflecting a remuneration policy designed to directly link the goals of employees and employers.

The optimal level of effort and payoffs is determined in a standard way in agency theory, such that the principal maximises her expected profit, subject to an incentive compatibility constraint and a participation constraint. The incentive compatibility constraint states that the optimal effort level provided by the agent maximises his certain equivalent. The participation constraint stipulates that the agent will accept the contract offered by the principal as long as his certain equivalent within the contract is higher than his outside wage. Under a linear payment scheme, both of these constraints are specified via the evaluation of  $\alpha$ , which determines the incentive compatibility constraint, and  $\beta$ , which determines the participation constraint.

$\alpha$  is derived by maximising the agent's certain equivalent. Agents are risk averse and exhibit the following exponential utility function: for an income level  $I$ ,  $U(I) = -\exp(-rI)$ , where  $r$  is the coefficient of the agent's absolute risk aversion. According to Holmström and Milgrom (1987), this specification implies that the agent's certain equivalent is simply equal to his mean return minus a risk premium, given by  $\frac{r}{2}\alpha_i^s \varphi^2$ <sup>5</sup>.

We assume that both tasks are independent, hence the effort expended at each task is independent of the effort expended at the other task (in this framework, no problem of moral hazard is present within teams). An agent's certain equivalent is thus given by:

$$CE^s = \alpha_i^s (e_i^s + e_{-i}^s) + \beta_i^s - C(e_i^s) - \frac{r}{2} (\alpha_i^s)^2 \varphi^2$$

---

<sup>5</sup>A general and simple proof of this property is given in Milgrom and Roberts, 1992, p.247.

Maximising this expression over  $e_i^s$  yields the *incentive compatibility constraint* as follows:

$$\alpha_i^s = ce_i^s$$

$\beta_i^s$  is determined by substituting this value into the certain equivalent and setting the expression equal to the agent's reservation wage, which for sake of simplicity is assumed to be zero. Thus,  $\beta$  is such that the *participation constraint is binding*.

The linear wage is then given by:

$$w_i^s(y^s) = ce_i^s(y^s - e_i^s - e_{-i}^s) + \frac{r}{2}(ce_i^s)^2\varphi^2 + \frac{c(e_i^s)^2}{2}$$

The optimal effort level required by the principal can now be determined by maximising the principal's expected payoff, subject to the previous constraints. This payoff is given by:

$$E\Pi^s = e_i^s + e_{-i}^s - w_i^s(e_i^s + e_{-i}^s) - w_{-i}^s(e_i^s + e_{-i}^s)$$

Maximising it with respect to  $e_i^s$  yields:

$$e_i^{s*} = \frac{1}{c(1 + rc\varphi^2)} \quad (2)$$

We observe that the optimal effort is strictly positive. Free-riding is therefore not an equilibrium strategy in this model, as opposed to basic models with moral hazard.

The optimal share parameter is then given by:

$$\alpha_i^{s*} = \frac{1}{1 + rc\varphi^2} \quad (3)$$

The agents' and the principal's expected payoffs can be expressed as:

$$EW^{s*} = \frac{1}{2c(1 + rc\varphi^2)} \quad (4)$$

$$E\Pi^{s*} = \frac{1}{c(1 + rc\varphi^2)} \quad (5)$$

Let us now consider a multi-task delegation mode, where both tasks are delegated to one worker.

## 2.2 The multi-task organisation with complementarity between tasks

The impact of new organisational forms on productivity has been the subject of recent empirical studies. Innovative work practices, especially through the development of team-work, are shown to improve performance. When considering a firm's work policy not in isolation but rather as part of a coherent incentive system, then innovative human resources management practices appear to be significantly productivity-improving (Ichnioswky, Shaw and Prennusch, 1997).

In the present paper, we capture this idea by assuming that delegating both tasks to one agent, in association with performance-based compensation, may yield a higher expected joint surplus. However, this element is highly dependent on the agents' multi-skilling ability. If workers were not well enough skilled to perform both tasks, there would be no point in delegating several projects to them. The basic mechanism behind this positive impact of multi-tasking on performance lies in the assumption that tasks are complementary. To formalise this complementarity between tasks in our model, we postulate that increasing effort expended on one task reduces the marginal cost of effort for the other task.

The observable output is once again given by:

$$y^m = e_1^m + e_2^m + \varepsilon$$

with  $e_1^m$  denoting the amount of effort expended by the agent at task 1,  $e_2^m$  his effort on task 2, and  $\varepsilon$  the error term, as defined above.

The cost function is quadratic with respect to the level of effort expended by the agent when performing both tasks:

$$C(e_1^m, e_2^m) = \frac{1}{2}c [(e_1^m)^2 + (e_2^m)^2] - \theta ce_1^m e_2^m \quad (6)$$

Several remarks can be made as regards this cost function.

The first is that this function is identical to the one considered in the specialised organisation, when assuming that for agent 1 :  $e_2 = 0$ , and for agent 2:  $e_1 = 0$ . Alternative cost functions could also have been used. For instance, we could have adopted a specification where  $C(e_1^m, e_2^m) = \frac{1}{2}c [e_1^m + e_2^m]^2 - \theta ce_1^m e_2^m$ . It can be shown that this cost function implies that the total effort expended by an agent is not affected by the number of tasks assigned to him, provided this total amount remains constant.

This mechanism however does not correspond with our basic assumption that effort is an imperfectly observable variable, which by essence is not constant. A constant effort level reflects production without moral hazard, which does not conform with the framework adopted herein. Furthermore, it would imply the agent's indifference regarding the internal distribution of the bundle of tasks, which is probably not true, especially in organisations where a higher delegation of tasks constitutes a means for motivating employees.

The second remark concerns the parameter  $\theta$ . In this specification,  $0 < \theta < 1$  represents the degree of complementarity between tasks. Increasing effort expended on one task reduces the marginal cost of effort on the other task. In Itoh's model (1994), the exact opposite has been assumed: tasks are not complementary but rather substitutable, and increasing effort on one task increases the marginal cost of effort on the other. The debate over which of these two assumptions better reflects work organisation is naturally open without necessarily any definitive resolution. However, the specificity of our model lies in its focus on studying the impact of innovative work practices on earnings. Backed by empirical studies, we consider that multi-skilling and multi-tasking induce productivity gains, which take the form of task complementarity. As forwarded by Lindbeck and Snower (1996), performing several tasks enables the agent to benefit from for example informational complementarities which increase labour productivity. Broadening workers' bundle of tasks improves both on-the-job learning and information sharing.

The other basic specifications of this model remain identical to the specialised organisation. The agent's payment scheme is again linear, and of the following form:

$$w^m(y^m) = \alpha^m y^m + \beta^m$$

Moreover, the agent's certain equivalent is given by:

$$CE^m = \alpha^m(e_1^m + e_2^m) + \beta^m - C(e_1^m, e_2^m) - \frac{r}{2}(\alpha^m)^2 \varphi^2$$

**Proposition 1 (Symmetry)**

*In the multi-task organisation, the optimal effort levels are symmetric:*

$$e_1^{m*} = e_2^{m*} = e^{m*}.$$

Proof. Deriving the agent's certain equivalent with respect to  $e_i^m$  yields:

$$\alpha^m = (1 - \theta)ce_i^m \text{ for } i = \{1, 2\}. \blacksquare$$

This symmetry property implies that it is optimal for the agent to place equal emphasis on both tasks. Using this property, the incentive compatibility constraint can be written as:

$$\alpha^{m*} = ce^{m*}(1 - \theta)$$

$\beta^{m*}$ , on the other hand, is such that the participation constraint is binding.

The optimal effort and payoff levels are determined using the same standard technique as above. We maximise the principal's expected payoff subject to both the incentive compatibility and participation constraints.

The optimal variables are then given by:

$$EW^{m*} = E\Pi^{m*} = e^{m*} = \frac{2}{c(1 - \theta)(2 + rc\varphi^2(1 - \theta))} \quad (7)$$

$$\text{and } \alpha^{m*} = \frac{2}{(2 + rc\varphi^2(1 - \theta))} \quad (8)$$

We now turn our attention to analysing the impact of innovative work practices, as characterised by complementarity between tasks and incentive compensation, on expected output and payoffs.

### 3 New work organisation, learning and inequality

The main issue to cope with is the extent of earnings inequality induced by a higher delegation of tasks in new work organisations by comparison with specialised ones. Answering this question requires in particular to specify the role of skills and learning.

Up until now, we have been considering a static model very similar to that in Itoh (1994), except for the interpretation of  $\theta$ . However, one can observe that the role played by  $\theta$  in our set-up is significant. A natural extension of this model, which deviates from Itoh's basic framework (1994), is to endogenise  $\theta$ . It is important to convey a clear and specific interpretation of the economic mechanism behind this complementarity. From this viewpoint, we focus on the required multi-skilling of job design in order for  $\theta$  to be positive. For a worker to be able to perform various tasks, he must indeed possess the requisite skills. This perception remains at the heart of the debate on skill-biased technological change. Simply stated, new technology requires more skilled employees, thereby shifting both the demand for skills and the

corresponding wage upward. However, when considering work organisation practices, focusing on demand shifts alone is insufficient by virtue of neglecting to incorporate job design. This is the reason why we have chosen to abstract from employment considerations and to focus on task delegation.

In our model, given that task complementarity and skills are intimately related, formalisation is achieved by assuming a learning process, according to which workers learn to be more efficient at distinct tasks by being assigned several tasks to perform. However, as noted by Lindbeck and Snower (1995), informational and knowledge task complementarities only become apparent over time. This is the reason why we have introduced a dynamic specification for  $\theta$ , in the form of an intertemporal externality of learning-by-doing.

Introducing time into the model does not change the results derived previously, except that each variable is now indexed by the subscript  $t$ . As a matter of fact, although the agents have an infinite life duration, a contract between principal and agent only lasts one period; a new contract between the principal and her agent has to be signed after one period.

### 3.1 Endogenous complementarity: the role of learning by doing

Task complementarities are endogenised according to the following relationship:

$$\theta_t = \frac{e_{t-1}}{2} \left( 1 - \frac{e_{t-1}}{2} \right) \quad (9)$$

where  $0 < \theta_t < 1$ .

In this specification,  $\theta_t$  depends on two components. The first one,  $\frac{e_{t-1}}{2}$ , indicates that a share of the level of effort (which is set at 0.5 in order to simplify the analysis) in period  $t-1$  exerts a positive externality on labour productivity, incorporated into  $\theta$ , in period  $t$ . This externality arises as knowledge is disseminated, and as workers acquire expertise through working.  $\frac{e_{t-1}}{2}$  is thus a measure of the knowledge dissemination effect. Considering that agents are ascribed one unit of time, the other component  $(1 - \frac{e_{t-1}}{2})$  represents the voluntary time spent on on-the-job learning, e.g. learning how to operate machines or simply how to perform the job. Both of these components can be seen as a "doing and learning" externality that affects labour productivity. The overall impact of  $e_{t-1}$  on  $\theta_t$  is positive, exhibiting a positive global externality due to the dissemination of learning-by-doing.

Given equation (9), a dynamic relationship now exists between the optimal effort level  $e_t$  determined in equation (7) and  $e_{t-1}$  (superscript  $m$  has been omitted for notational simplicity):

$$e_t = \frac{2}{c \left\{ 1 - \frac{e_{t-1}}{2} \left( 1 - \frac{e_{t-1}}{2} \right) \right\} \left\{ 2 + rc\varphi^2 \left[ 1 - \frac{e_{t-1}}{2} \left( 1 - \frac{e_{t-1}}{2} \right) \right] \right\}} \quad (10)$$

The dynamics of  $e_t$  are as follows. A first-order differential equation is obtained; due to its non-linearity, we apply a qualitative-graphic analysis in order to determine the convergence or divergence of  $e_t$  towards its steady-state value using the methodology presented in Chiang (1984). Equation (10) can be generally represented by the functional relationship  $e_t = f(e_{t-1})$ . The time path of  $e_t$  can be displayed in the following phase diagram:

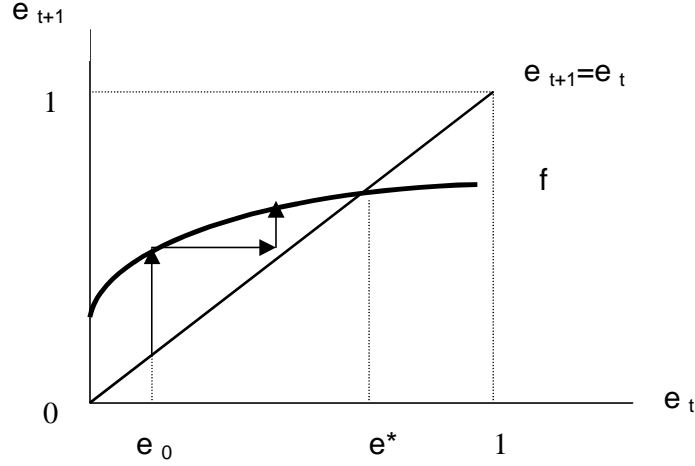


Figure 2: Phase diagram

The algebraic sign of the slope of the phase line (the curve corresponding to  $f$ ) determines whether an oscillation will occur; and the absolute value of its slope governs the convergence towards the steady-state value of  $e_t$ ,  $e^*$ . After some simple algebraic steps, we obtain:

$$f'(e_{t-1}) = \frac{2(1 - e_{t-1}) \left[ 1 + rc\varphi^2 \left[ 1 - \frac{e_{t-1}}{2} \left( 1 - \frac{e_{t-1}}{2} \right) \right] \right]}{c \left\{ 1 - \frac{e_{t-1}}{2} \left( 1 - \frac{e_{t-1}}{2} \right) \right\}^2 \left\{ 2 + rc\varphi^2 \left[ 1 - \frac{e_{t-1}}{2} \left( 1 - \frac{e_{t-1}}{2} \right) \right] \right\}^2}$$

**Proposition 2 (Dynamics of effort)**

$e_t$  converges monotonically towards its steady-state value of  $e^*$ .

Proof.

It is straightforward to observe that  $f' > 0$ , which implies that the time path of  $e_t$  is monotonic and does not oscillate.

Moreover,  $f' < 1$ , which implies that the time path is convergent.

$f'$  can be written as follows:

$$f'(e_{t-1}) = \frac{2}{c \left\{ 1 - \frac{e_{t-1}}{2} \left( 1 - \frac{e_{t-1}}{2} \right) \right\} \left\{ 2 + rc\varphi^2 \left[ 1 - \frac{e_{t-1}}{2} \left( 1 - \frac{e_{t-1}}{2} \right) \right] \right\}} \cdot \frac{1 + rc\varphi^2 \left[ 1 - \frac{e_{t-1}}{2} \left( 1 - \frac{e_{t-1}}{2} \right) \right]}{2 + rc\varphi^2 \left[ 1 - \frac{e_{t-1}}{2} \left( 1 - \frac{e_{t-1}}{2} \right) \right]} \cdot \frac{1 - e_{t-1}}{1 - \frac{e_{t-1}}{2} \left( 1 - \frac{e_{t-1}}{2} \right)}$$

The first term of  $f'$  is equal to  $e_t$  and is thus strictly lower than 1 by definition. It can be easily verified that the second and third terms of  $f'$  are also strictly lower than one. Thus,  $f' < 1$ . ■

One particularity of this time path is that it counters the traditional “ratchet effect” which arises when workers, in foreseeing the way future standards will depend on current performance, may refuse to cooperate with efforts to improve productivity (Milgrom and Robert, 1992). Within our framework, since current efforts positively influence future performance, it remains optimal to cooperate with strictly positive effort levels. If instead we were to assume a negative relationship between  $e_{t-1}$  and  $\theta_t$ , we would naturally obtain the opposite effect. It is interesting to note that the formalisation of a learning curve provides an incentive to increase effort levels, thereby preventing free-riding and the “ratcheting up” of standards in a dynamic perspective. It also shows that innovative work practices associated with learning stimulation generate a virtuous cycle between effort and productivity.

### 3.2 Is organisational change skill-biased?

First, by distinguishing a risk-premium effect and a task complementarity effect, it can be shown that multi-tasking increases within-group inequality. Secondly however, in a dynamic perspective taking into account the learning process, it should be noted that the skill bias due to organisational change depends on the initial level of effort. An



analytical comparison of expected payoffs when  $\theta$  is both exogenous and endogenously determined by past efforts has yielded the following results:

**Proposition 3 (Comparative statics: specialisation vs. multi-tasking)**

(i) *The risk-premium effect*

*Delegating both tasks to one agent, in the absence of task complementarity, induces higher effort levels and greater expected payoffs for both parties.*

(ii) *The complementarity effect*

*Multi-tasking which induces complementarity between tasks also increases expected output and payoffs.*

Proof. (i) It is straightforward to observe that  $e^{m*}(\theta = 0) > e^{s*}$ ,  $EW^{m*}(\theta = 0) > EW^{s*}(\theta = 0)$ , and  $E\Pi^{m*}(\theta = 0) > E\Pi^{s*}(\theta = 0)$ .

(ii) Similarly, we have  $e^{m*}(\theta) > e^{s*}$ ,  $EW^{m*}(\theta) > EW^{s*}(\theta)$ , and  $E\Pi^{m*}(\theta) > E\Pi^{s*}(\theta)$ .

Furthermore, expected output and payoffs are increasing in  $\theta$  :  $\frac{\partial EW^{m*}}{\partial \theta} > 0$ , and  $\frac{\partial E\Pi^{m*}}{\partial \theta} > 0$ . ■

Part (i) of proposition 3 implies that, even without any cost complementarity between tasks, it is profitable for the principal to delegate both tasks to one agent. This result confirms Itoh's analysis (1994), though a cost complementarity parameter need not be introduced. The reason lies in the fact that when the two tasks are delegated to two different agents, the risk-sharing rule implies that the principal and both agents individually obtain a lower share of the surplus (the risk premium is hence taken into account twice, once for each agent). In contrast, when delegating both tasks to one single agent, both principal and agent can reach a higher share of the surplus since the risk premium is being borne only once.

Part (ii) of proposition 3 shows that a multi-task organisation provides greater incentives to effort through the learning process it favours. However, it also fosters inequality within skill groups, i.e. across firms. This model substantiates the conclusions of the former analysis by Itoh (1994). When choosing the type of work organisation, the principal will undeniably adopt a multi-task form (it should however

be noted that the analysis of the motivation to adopt a new organisation is far beyond the scope of this article). The comparison between multi-tasking and specialisation represents simply a comparative statics analysis: it shows that adopting new work practices will induce higher expected payoffs, as compared to a benchmark situation (the specialised work organisation).

Our result that firms using innovative work practices pay higher wages is consistent with the econometric study provided by Black and Lynch (2000). Using a representative sample of U.S. establishments surveyed in 1993 and 1996, these authors observed that incentive schemes are important, and more precisely that firms “do need to compensate workers for participating in these workplace practices which increase productivity”. Various forms of compensation (stock options, profit sharing) associated with higher wages are indeed present. Cappelli and Neumark (1999) found that innovative work practices induce benefits to employees in relation to employee involvement, in the form of higher compensation.

**Proposition 4 (Dynamics of payoffs with the learning process)**

*In the transition towards their steady-state values, the principal's and the agent's payoffs monotonically increase when the initial effort level is below steady-state value, and decrease otherwise.*

Proof. From equation (7), we have ascertained that both the principal's and the agent's expected payoffs are governed by the same equation as that of the effort. The dynamics of  $EW_t$  and  $E\Pi_t$  are therefore identical to the dynamics of  $e_t$ . Thus,  $EW_t$  and  $E\Pi_t$  monotonically converge to their steady-state values  $EW^*$  and  $E\Pi^*$ , respectively. Whether  $EW_t$  and  $E\Pi_t$  increase or decrease during the transition towards steady-state depends on the initial value of  $e_0$ . Payoffs increase if  $e_0 < e^*$  and decrease if  $e_0 > e^*$ . ■

Innovative work practices often get implemented to achieve productivity gains, i.e. when initial performance is relatively low. In this case, innovative human resources management may lead to significant productivity gains and increasing payoffs over time, until steady-state is reached. Yet, in initially high-effort, high-productivity firms, implementing innovative work organisation practices will lead to decreasing efforts and payoffs until steady-state is reached. Thus, organisational change does not ineluctably foster wage inequality within groups over time.

## 4 Conclusion

This paper has shown that for incentive-based reasons, a principal may attain a higher profit level and higher joint surplus by implementing multi-tasking. Even in the absence of cost complementarity between tasks, it is profitable for the principal to delegate both tasks to one single agent. A multi-task organisation provides greater incentives to expend effort through higher wages; however, it also increases inequality within groups. The basic reason lies in the complementarity between tasks being generated by multi-tasking. A dynamic learning-by-doing process can generate a virtuous cycle between effort, productivity and payoffs. By providing workers with multiple skills, this positive intertemporal externality generates a positive endogenous relationship between innovative work practices, productivity, effort and payoffs.

This result is consistent with the observations of Ichnioswky, Shaw and Prennusch (1997), for steel finishing lines that “workers’ performance is substantially better under incentive pay plans that are coupled with supporting innovative work practices - such as flexible job design, employee participation in problem-solving teams, training to provide workers with multiple skills (...) than it is under more traditional work practices”.

Yet, organisational innovation does not automatically foster wage inequality. Our model shows that this consideration depends on whether the initial effort and productivity levels are relatively high (above their steady-state values) or low (below steady-state values). If the level of effort was initially large, the motivation to raise compensation incentives disappears and inequality declines.

## References

- [1] Acemoglu D., (1998), “Why do New Technologies Complement Skills? Directed Technical Change and Wage Inequality”, *Quarterly Journal of Economics*, 113: 1055-1089.
- [2] Aghion P., E. Caroli, and C. García-Peñalosa, (1999), “Inequality and Economic Growth: The Perspective of the New Growth Theories”, *Journal of Economic Literature*, 37(4): 1615-1660.
- [3] Appelbaum E. and R. Batt, (1994), *The New American Workplace: Transforming Work Systems in the United States*, ILR Press, Ithaca, New York.
- [4] Askenazy P., (1998), “The Neo-Stakhanovism”, *CREST-NBER Conference on New Information and Communication Technologies, Employment and Earnings*, Nice, June 22-23.
- [5] Berman E., J. Bound and Z. Griliches, (1994), “Changes in the Demand for Skilled Labor within U.S. Manufacturing: Evidence from the Annual Survey of Manufactures”, *Quarterly Journal of Economics*, 109: 367-397.
- [6] Betts J.R., (1997), “The Skill Bias of Technological Change in Canadian Manufacturing Industries”, *Review of Economics and Statistics*, 79(1): 146-150.

- [7] Black S. and L. Lynch, (2000), "What's Driving the New Economy: The Benefits of Workplace Innovation", *NBER Working Paper* No. 7479.
- [8] Bresnahan T., E. Brynjolfsson and L. Hitt, (1998), "Informational Technology, Workplace Organization and the Demand for Skilled Labor: Firm Level Evidence", mimeo, Stanford University.
- [9] Cappelli P. and D. Neumark, (1999), "Do 'High Performance' Work Practices Improve Establishment-Level Outcomes?", *NBER Working Paper* No.7374.
- [10] Caroli E., N. Greenan and D. Guellec, (1997), "Organisational Change and Human Capital Accumulation", *CEPREMAP Working Paper* 9719.
- [11] Caroli E. and J. Van Reenen, (1999), "Skill and Organizational Change: Evidence from British and French Establishments in the 1980s and 1990s", mimeo.
- [12] Chennels L. and J. Van Reenen, (1998), "Technical Change and the Structure of Employment and Wages: A Survey of the Micro-Econometric Evidence", *CREST-NBER Conference on New Information and Communication Technologies, Employment and Earnings*, Nice, June 22-23.
- [13] Chiang A., (1984), *Fundamental Methods of Mathematical Economics*, McGraw-Hill, 3rd edition.
- [14] Crifo-Tillet P., (2000), "Incentives and Wage Inequality in a Model of Endogenous Growth with Organizational Change", *Econometric Society World Congress*, Seattle, August 11-16.
- [15] Crifo-Tillet P. and M.C. Villeval, (1999), "Organizational Change, Skill Supply and Inequality", *European Association of Labour Economists (EALE)*, Regensburg, September 23-26.
- [16] Doms M., T. Dunne and K. Troske, (1997), "Workers, Wages and Technology", *Quarterly Journal of Economics*, 112(1): 253-290.
- [17] Greenan N., (1996), "Progrès technique et changements organisationnels: leur impact sur l'emploi et les qualifications", *Economie et Statistique*, 298: 35-44.

- [18] Helpman E. and M. Trajtenberg, (1994), "A Time to Sow and a Time to Reap: Growth Based on General Purpose Technologies", *NBER Working Paper*, No.4854.
- [19] Holmström B. and P. Milgrom, (1994), "The Firm as an Incentive System", *American Economic Review*, 84(4), 972–991.
- [20] Holmström B. and P. Milgrom, (1991), "Multi-task Principal-Agent Analyses: Incentive Contracts, Asset Ownership and Job Design", *Journal of Law, Economics and Organization*, 7: 24-52.
- [21] Holmström B. and P. Milgrom, (1987), "Aggregation and Linearity in the Provision of Intertemporal Incentives", *Econometrica*, 55(2): 303-328.
- [22] Ichniowsky C., K. Shaw and G. Prennushi, (1997), "The Effects of Human Resources Management Practices on Productivity: A Study of Steel Finishing Lines", *American Economic Review*, 87(3): 291-314.
- [23] Itoh H., (1994), "Job Design, Delegation, and Cooperation: A Principal-Agent Analysis", *European Economic Review*, 38: 691-700.
- [24] Itoh H., (1992), "Cooperation in Hierarchical Organizations: An Incentive Perspective", *Journal of Law, Economics and Organization*, 8(2): 321-345.
- [25] Kremer M. and E. Maskin, (1996), "Wage Inequality and Segregation by Skill", *NBER Working Paper* No.5718.
- [26] Lindbeck A. and D. Snower, (1996), "Reorganization of Firms and Labour-Market Inequality", *American Economic Review, Papers and Proceedings*, 86(2): 315-321.
- [27] Lindbeck A. and D. Snower, (1995), "Restructuring Production and Work", mimeo.
- [28] Milgrom P. and J. Roberts, (1992), *Economics, Organization and Management*, Prentice-Hall, Englewood Cliffs, New Jersey.
- [29] Salanié B., (1997), *The Economics of Contracts, A Primer*, Cambridge, The MIT Press.

- [30] Snower D.J., (1999), “The Organizational Revolution and its Labor Market Implications”, *Keynote address to the European Association of Labour Economists (EALE)*, Regensburg, September 23-26.